

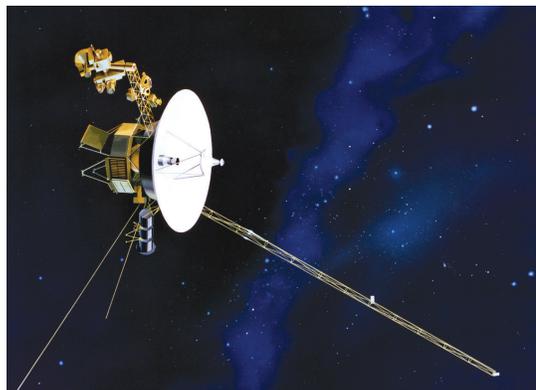


Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)

Space exploration missions require safe, reliable, long-lived power systems to provide electricity and heat to spacecraft and their science instruments. A flight-proven capable source of power is the Radioisotope Thermoelectric Generator (RTG)—essentially a nuclear battery that reliably converts heat into electricity.

NASA and the Department of Energy (DOE) have developed a new generation of such power systems that could be used for a variety of space missions. The newest RTG, called a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG), has been designed to operate in space environments and in the vacuum of space. The MMRTG has a flexible modular design capable of meeting the needs of a wide variety of missions, as it generates electrical power in smaller increments than previous generations of RTGs, about 110 watts at launch. The design goals for the MMRTG included optimizing power levels over a minimum lifetime of 14 years and ensuring a high degree of safety.

counting. The Apollo missions to the moon, the Viking and Curiosity missions to Mars, and the Pioneer, Voyager, Ulysses, Galileo, Cassini and Pluto New Horizons missions to the outer Solar System all used RTGs. The RTGs for the Pioneer 10 spacecraft operated flawlessly for three decades until the spacecraft signal was finally too weak to detect in 2003. The spectacular Voyager 1 and 2 missions, operating on RTG power since launch in 1977, continue to function, with Voyager 1 and 2 just having reached interstellar space.

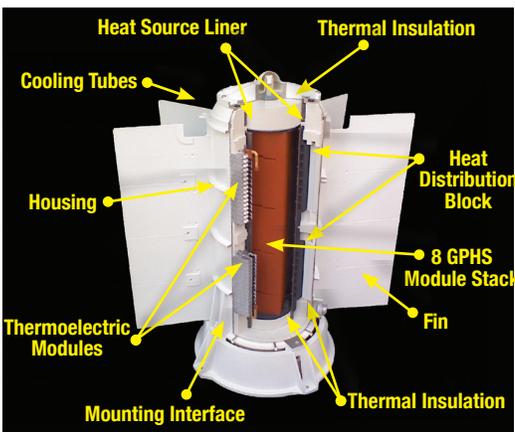


An artist impression of Voyager 1

How RTGs Work

RTGs work by converting heat from the natural decay of radioisotope materials into electricity. RTGs consist of two major elements: a heat source that contains plutonium-238 (Pu-238) and solid-state thermocouples that convert the plutonium's decay heat energy to electricity.

Conversion of heat directly into electricity is a scientific principle discovered 150 years ago by German scientist Thomas Johann Seebeck. He observed that an electric voltage is produced when two dissimilar, electrically conductive materials are joined in a closed circuit and the two junctions are kept at different temperatures. Such pairs of junctions are called thermoelectric couples (or thermocouples).



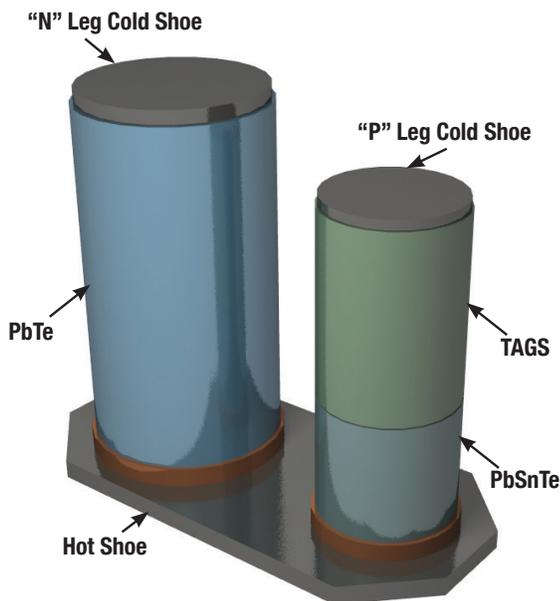
MMRTG Model

History of RTGs in Space

First launched into Earth orbit in 1961, RTGs have flown on 27 space missions involving 46 RTGs. RTGs have enabled NASA to explore the Solar System for four decades and

NASAfacts

The power output from such thermocouples is a combination of the temperature of each junction and the properties of the thermoelectric materials. The thermocouples in RTGs use heat from the decay of Pu-238 to heat the hot side of the thermocouple, and the cold of space or a planetary atmosphere to produce a low temperature at the cold side.

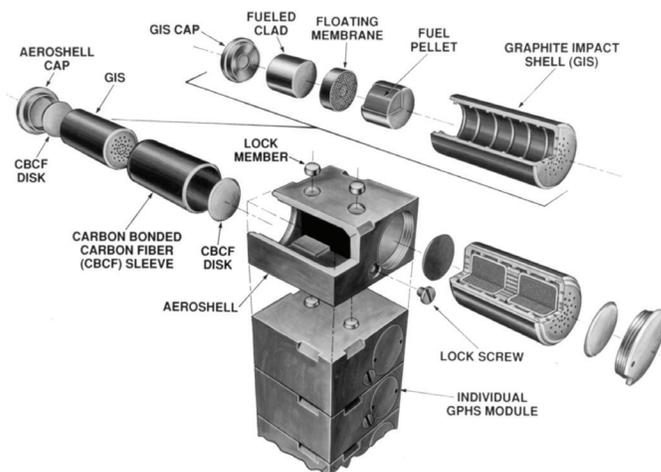


MMRTG Thermoelectric Couple

Safety and Design of RTGs

The MMRTG is designed to use a heat source composed of eight General Purpose Heat Source (GPHS) modules. These GPHS modules are the basic building block of safety for Radioisotope Power Systems. While RTGs have never been the cause of a spacecraft accident, they have been on board three space missions that failed for other reasons. In all three cases, the RTGs performed precisely as designed.

The MMRTG contains a total of 10.6 pounds (4.8 kilograms) of plutonium dioxide (including Pu-238) that initially provides approximately 2,000 watts of thermal power and 110 watts of electrical power when exposed to deep space environments. The thermoelectric materials (PbSnTe, TAGS, and PbTe) have demonstrated extended lifetime and performance capabilities, and are the same as those used for the two Viking spacecraft that landed on Mars in 1976. The MMRTG generator is about 25 inches (64 centimeters) in diameter (fin-tip to fin-tip) by 26 inches (66 centimeters) tall and weighs about 94 pounds (45 kilograms)



GPHS Module Illustration provided by DOE

MMRTG Mission Planner Data Package

A Mission Planner's Users Guide has been developed to provide details of how to integrate the MMRTG into a mission. Mission Planners are encouraged to submit a request to the RPS Program to receive the MMRTG Mission Planner Data Package. *Only one new individual per organization will be granted access to the data package.* The definition of an "organization" is subject to the discretion of the RPS Program and DOE (i.e., a large company with major offices on the east and west coasts may be permitted to have one library member per office). In addition, requester must be a **U.S. Person** (U.S. Citizen or Legal Permanent Resident, Green Card holder, etc.) and **demonstrate valid need** for data package. <https://rps.nasa.gov/resources/74/mmrtg-mission-planner-data-package/?category=reports>

Both forms, the Data Package Request and the User Agreement, but be emailed to rps@nasa.gov for consideration.

Announcement of Opportunity Point of Contact:

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For more information about NASA's use of Radioisotope Power Systems, see: rps.nasa.gov or email rps@nasa.gov